Drug Use Evaluation of Moxifloxacin (Avelox) Using a Hand-Held Electronic Device At a Canadian Teaching Hospital

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ABSTRACT

Background: The use of moxifloxacin (Avelox) has increased at Vancouver General Hospital since its introduction onto the formulary in 2002. It is unclear, however, whether the use of the drug is optimal according to its indication. Hand-held electronic devices, such as personal digital assistants (PDAs), are novel tools that can be used during routine patient care to collect data for drug use evaluation (DUE) reviews.

Objective: We hypothesized that moxifloxacin was overutilized and that opportunities existed to optimize its use. This study was designed to characterize moxifloxacin use in concordance with evidence-based assessment criteria. The feasibility of using a PDA device as a data-collection tool was also evaluated.

Design: An observational DUE was conducted over a 4-week period (from February 17 to March 16, 2007) at Vancouver General Hospital, a 955-bed tertiary care hospital. Inpatients who received at least one dose of moxifloxacin were enrolled. Evidence-based assessment criteria were developed to evaluate the appropriateness of moxifloxacin use, and a PDA database was developed for data collection. The primary endpoint was the proportion of moxifloxacin use for approved first-line indications.

Results: A total of 132 patients were included. Eighty-nine patients (67%) received moxifloxacin for first-line indications, including community-acquired pneumonia (57%) and acute exacerbation of chronic bronchitis (10%). Forty-three patients (33%) had alternative indications, primarily hospital-acquired pneumonia (25%). In 129 evaluable patients, approximately half (51%) of the clinical outcomes were successful; 37% were indeterminate; and 12% were failures. General medicine and respiratory service clinicians prescribed moxifloxacin more appropriately compared with surgical service personnel. Most of the pharmacists supported the use of PDAs as DUE data-collection tools.

Conclusion: Overall, moxifloxacin utilization at Vancouver General Hospital was appropriate according to evidence-based assessment criteria. Additional opportunities to improve its use exist through health care staff education. PDAs are ideal data-collection tools for DUEs, as they can be conveniently used during routine patient care.

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Accepted for publication January 8, 2012.

INTRODUCTION

Moxifloxacin

Moxifloxacin (Avelox, Bayer) is a fluoroquinolone antibiotic with activity against respiratory pathogens. In Canada, moxifloxacin is approved for the treatment of acute exacerbations of chronic bronchitis (AECB), acute bacterial sinusitis (ABS), community-acquired pneumonia (CAP), complicated intra-abdominal infections (IAIs), and complicated skin and skin structure infections (SSSIs).[1,2]

At Vancouver General Hospital, moxifloxacin use has increased since its addition to the formulary in 2002, when it replaced levofloxacin (Levaquin, Ortho-McNeil/Janssen). During fiscal year 2009–2010, the cost of moxifloxacin exceeded $200,000 (in Canadian dollars), accounting for approximately 5% of the total annual anti-infective expenditures of $4 million. In previous studies of fluoroquinolones, high rates of suboptimal use (from 31% to 81%) had been reported.[3–10] The utilization characteristics of moxifloxacin had not been formally assessed at our institution, and it was unclear whether its use was optimal based on its therapeutic indication.

Drug Use Evaluation

Drug use evaluation (DUE) is a systematic approach that assesses the appropriateness, safety, and effectiveness of a medication to improve patient care.[11] Optimizing medication utilization has the potential to reduce the development of antimicrobial resistance and to lower overall health care costs by providing cost-effective treatments.[11] Traditionally, DUEs have involved paper-based, retrospective reviews of patient health records. This method is labor-intensive and inefficient, because information is manually retrieved, reviewed, and re-

Disclosure: The authors report that they have no financial, commercial, or industrial relationships to disclose in regard to this article.

entered into an electronic format. Other drawbacks include the potential for missing information and an overreliance on the investigators' interpretation of archived data. In addition, results from retrospective DUEs might not reflect the drug's current usage.

Personal Digital Assistants

Compared with paper-based systems, hand-held electronic devices or personal digital assistants (PDAs), when used to conduct DUEs during routine patient care, represent a novel approach that offers several advantages. Data are more recent and complete, and they can be captured with greater efficiency into a readily analyzable electronic format. Prospective data may also be more robust than a retrospective review, because PDA users have the opportunity to clarify data in patients' medical records with health care practitioners. Only a few studies have assessed the utility of PDAs as data-collection tools for DUEs.[12]

Hypothesis and Objective

We hypothesized that moxifloxacin was being overutilized at Vancouver General Hospital and that opportunities existed to optimize its use. Accordingly, our study aimed to characterize moxifloxacin use at our institution in concordance with evidence-based assessment criteria. We also evaluated the feasibility of PDAs as data-collection tools.

METHODS

Design and Site

Our observational, retrospective DUE was conducted at Vancouver General Hospital, a 955-bed, tertiary-care, university-affiliated teaching facility in Vancouver, British Columbia, Canada. Ethics and research approvals were granted by the Clinical Research Ethics Board of the University of British Columbia and by the Vancouver Coastal Health Research Institute. We conducted the study over a 4-week period, from February 17 to March 16, 2007. Patients who received at least one dose of moxifloxacin in an acute inpatient ward were enrolled.

Development of Assessment Criteria

Evidence-based assessment criteria were developed to evaluate the appropriateness of moxifloxacin use. We performed a literature search of Medline, EMBASE, and PubMed from 1966 to November 2006 using the search term "moxifloxacin" with predefined search filters.[13] We identified and reviewed a total of 1,023 citations, yielding 74 relevant citations (37 randomized controlled trials, 24 cohort or observational studies, seven case reports, three systematic reviews, and three practice guidelines).

Relevant articles were sorted by therapeutic indication and were classified according to the Infectious Diseases Society of America (IDSA) grading system to create three "levels of evidence" criteria[14] (Table 1).

After levels of evidence were established for each thera-

Table 1 Evidence-Based Assessment Criteria for Moxifloxacin

Indication	Level of Evidence[a]	Place in Therapy[b]
• Acute exacerbation of chronic bronchitis • Community-acquired pneumonia	I	First-line therapy
• Acute bacterial sinusitis • *Helicobacter pylori* peptic ulcer disease • Intra-abdominal infections • Skin and skin-structure infections	I	Alternative therapy
• Bacterial meningitis • Tuberculosis	II	Alternative therapy
• Hospital-acquired pneumonia • Q-fever pneumonia (*Coxiella burnetii*) • Ventilator-associated pneumonia	III	Alternative therapy

[a] **Level of Evidence** (based on the grading system for ranking recommendations in clinical guidelines):
- ***Level I:*** evidence from at least one properly randomized, controlled trial
- ***Level II:*** evidence from at least one well-designed clinical trial without randomization; from cohort-controlled or case-controlled analytical studies (preferably from multiple centers); from multiple time-series studies; or from dramatic results in uncontrolled experiments
- ***Level III:*** evidence from opinions of respected authorities, based on clinical experience, descriptive studies, or reports of expert committees

[b] **Place in Therapy:**
- First-line therapy: moxifloxacin should be the agent of choice.
- Alternative therapy: moxifloxacin is considered a therapeutic alternative when a first-line agent is documented to be contraindicated or inappropriate.

peutic indication, we determined the "place of therapy" for moxifloxacin use at our institution (see Table 1). We classified moxifloxacin as a first-line therapy when it was considered the agent of choice and as an alternative therapy when it was a therapeutic alternative to a first-line agent. The place of therapy for the various indications was endorsed by the Antibiotic Use Subcommittee at Vancouver General Hospital and was based on local standards of practice, the hospital's drug formulary, preprinted physician orders, antibiotic susceptibility patterns, and the opinion of experts in infectious diseases.

Development of the PDA Database

We developed the PDA database using Pendragon Forms (version 3.2). Palm Pilot Tungsten E/E2 models running Palm Operating System 5 were used for data collection. Data were collected on a single Pendragon Forms page. We entered the data fields using:

- *free text,* which included patients' initials; study subject number; antibiotic allergies; comorbidities; concomitant use of oral medications; significant adverse drug effects; and therapeutic indications.
- *drop-down lists*, which included:
  - clinical outcome achieved: success, indeterminate, or failure.
  - route of therapy.
  - type of therapy: directed, empirical, or prophylactic.

The PDA data that the clinical pharmacists collected were synchronized via a hard-wired connection to Pendragon Forms over the hospital network to a central server in the Department of Pharmaceutical Sciences. The frequency of synchronization by clinical pharmacists was variable, but data collection was completed before the end of the 4-week study period.

To maintain patient confidentiality, both the PDA and the Pendragon Forms software on the hand-held device were password-protected. The Department of Pharmaceutical Sciences and the Vancouver Coastal Health Research Institute considered this step to be adequate in protecting patient information.

Participating pharmacists were enrolled in a training session and received an information handout. A pilot test of data collection was performed by J.A.E.S. and D.H.T.E. over a 1-week period before study enrollment.

Data Collection

We identified patients from a pharmacy computer-system target drug report, which documented all patients who had started moxifloxacin the previous day. Clinical pharmacists performed data collection using PDAs during routine patient care, which was defined as providing pharmaceutical care activities in the wards and during patient rounds.

Patients were observed until the completion of therapy or hospital discharge. The pharmacy computer system was also used to identify patients who received moxifloxacin but who were not observed prospectively by clinical pharmacists during routine care.

Because of limited pharmacy resources and logistical problems, the pharmacists did not observe all inpatients. To provide a representative summary of moxifloxacin use from this second group, we collected data retrospectively from a random sample of paper-based medical records using a PDA. We documented the time required to collect these data. We collected data from non-computerized sources (e.g., information during routine care and paper-based medical records) and from the hospital patient-care information system (PCIS).

Noncomputerized data consisted of antibiotic allergies, outcomes (i.e., success, indeterminate, or failure), comorbidities, concomitant use of oral medications, route of administration, moxifloxacin adverse effects, therapeutic indications, and type of therapy (directed, empirical, or prophylactic). Using PDAs, clinical pharmacists collected the data during routine patient care.

Data collected from the PCIS included patient demographics (i.e., age, sex, admitting service, hospital ward, physician, and length of stay), medication use (i.e., dose, route of administration, and duration), and concomitant antibiotics. We extracted the data by synchronizing the PDAs to the database.

The final database was built in Microsoft Access 2003. Patients' records were exported from Pendragon Forms to Microsoft Access 2003 to allow the merging of these data with extracted data from the hospital's PCIS.

Definitions

The following terms were used to assess moxifloxacin utilization:

Type of therapy. Moxifloxacin treatment was defined as "directed" therapy when it was initiated based on culture and sensitivity results that targeted a known pathogen; as "empirical" therapy when the drug was initiated based on expected pathogens or on pending culture and sensitivity results; and as "prophylactic" therapy when it was used to prevent infection.

Clinical outcomes. Outcomes were assessed for all patients and were defined as follows:

- *Success:* Patients experienced (1) complete resolution of signs and symptoms of infection (improvement of all baseline parameters in the hospital or at discharge) or (2) significantly fewer signs and symptoms.
- *Indeterminate:* It was not possible to evaluate the patient's health status because of insufficient data (e.g., if a patient was discharged without clarification of his or her status).
- *Failure:* Patients experienced (1) persistent or worsening signs and symptoms of infection, requiring the initiation of an alternative anti-infective agent, or (2) no significant remission of signs and symptoms (no improvement in baseline parameters).

Serious adverse drug effects. Adverse effects referred to any untoward occurrence resulting from moxifloxacin that necessitated a change in therapy.

Study Endpoints and Survey

The primary endpoint was the proportion of moxifloxacin use in approved first-line indications compared with alternative indications. Secondary endpoints included:

- the proportion of successful, indeterminate, or failure out-

Table 2 Demographic Characteristics

No. of patients	132
Age (years), median (range)	73 (20–100)
Sex, n (%)	
Male	71 (53.8)
Female	61 (46.2)
Antibiotic allergy or intolerance, n (%)	
No known drug allergies	91 (68.9)
Penicillin/cephalosporin	26 (19.7)
Sulfonamide	15 (11.4)
Macrolide	4 (3.0)
Ciprofloxacin	3 (2.3)
Clindamycin	3 (2.3)
Tetracycline	2 (1.5)
Acyclovir	1 (0.8)
Bacitracin	1 (0.8)
Metronidazole	1 (0.8)
Quinine sulphate	1 (0.8)
Comorbidity, n (%)	
Respiratory disease (asthma, COPD)	40 (30.3)
Immunocompromised state	37 (28.0)
Hospitalized more than 48 hours before pneumonia	35 (26.5)
None	24 (18.2)
Diabetes mellitus	21 (15.9)
Recent non-fluoroquinolone antibiotic use (within 3 months)	21 (15.9)
Other concomitant infection	15 (11.4)
Recent hospitalization	14 (10.6)
Recent fluoroquinolone antibiotic use (within 3 months)	12 (9.1)
Arrhythmia/antiarrhythmic drugs	9 (6.8)
Chronic renal failure	6 (4.5)
Ventilated ICU patient	6 (4.5)
Seizure disorder	3 (2.3)
Service, n (%)	
General medicine	50 (37.9)
Respiratory	26 (19.7)
General surgery	10 (7.8)
Thoracic surgery	10 (7.8)
Cardiovascular	7 (5.3)
Orthopedics	6 (4.5)
Bone marrow transplantation	3 (2.3)
Neurology	3 (2.3)
ICU	3 (2.3)
Otolaryngology (ENT)	2 (1.5)
Palliative care	2 (1.5)
Tuberculosis	2 (1.5)
Urology	2 (1.5)
Trauma	2 (1.5)
Nephrology	1 (0.8)
Spine	1 (0.8)

COPD = chronic obstructive pulmonary disease; ENT = ears, nose, and throat; ICU = intensive-care unit.

comes achieved with the use of moxifloxacin as first-line therapy compared with its use as an alternative therapy.
- the type of therapy (directed, empirical, or prophylactic) and its clinical outcomes.
- the proportion of level II and III evidence utilization according to prescribing medical services.
- the duration of moxifloxacin therapy by indication.
- the proportion of patients receiving IV moxifloxacin and concomitant oral medications whose regimen was stepped down from IV to oral moxifloxacin.
- the incidence of serious adverse drug effects.
- satisfaction with PDAs as DUE data-collection tools.

To assess the utility of the PDA as a DUE data-collection tool, we sent a survey to all participating clinical pharmacists at the completion of the data-collection period.

Statistical Analysis

We performed descriptive statistical analyses using Microsoft Office Excel 2003.

RESULTS

Enrollment

We identified a total of 202 eligible patients. Pharmacists entered 136 records into the PDA database during routine patient care. We excluded 30 records for the following reasons: 18 patients received moxifloxacin outside of the study period; eight records were duplicate entries; and four records were incomplete. Thus, 106 completed records were included in the study (Figure 1). In an effort to collect representative data from the 96 patients who were not followed by clinical pharmacists, we randomly selected a convenience sample of 26 patients and collected data via a retrospective review of health care records. A total of 132 patients were included in the final analysis.

Patient Demographics

Demographic characteristics are listed in Table 2. Median patient age was 73 years (range, 20–100 years). Most patients (69%) did not have drug allergies. The most common comorbidity was respiratory disease (asthma or chronic obstructive pulmonary disease [COPD]), which was present in 30% of patients. Other comorbidities included an immunocompromised state (in 28%) and hospitalization more than 48 hours before pneumonia (in 27%). Moxifloxacin therapy was initiated predominantly by the general medicine, respiratory, and surgical services.

Primary Endpoint

Indications for moxifloxacin are summarized in Figure 2. Of the 132 patients in this study, 89 (67%) received moxifloxacin as a first-line therapy. Seventy-five patients (57%) were treated with first-line moxifloxacin for CAP, and the remaining 13 patients (10%) were treated for AECB. Forty-three patients (33%) received moxifloxacin as an alternative therapy for a variety of diseases, and hospital-acquired pneumonia (HAP) was the most common disease (25%). Other indications for alternative therapy included empyema, malignant pleural effusion, postoperative pulmonary surgery, tuberculosis, intra-abdominal infections, acute bacterial sinusitis, and SSSIs.

Secondary Endpoints

Outcomes. Outcome analyses were completed for 129 of the 132 patients. In this cohort, 51% of the clinical outcomes were successful, 37% were indeterminate, and 12% were failures. When moxifloxacin was used for approved indications as first-line therapy, successful outcomes were achieved in 49 of 85 patients (58%) (Figure 3). By contrast, when moxifloxacin was used as alternative therapy (mainly for HAP), the outcomes were considered indeterminate in 22 of 44 patients (50%).

Type of therapy. The use of moxifloxacin was empirical in 111 of the 129 patients (86%). Directed moxifloxacin therapy was provided in 17 patients (13%) and was successful in 12 of these patients (69%). Only one patient (less than 1%) received prophylactic treatment.

Service. According to Level I evidence, moxifloxacin was usually prescribed appropriately by general medicine and respiratory services in 45 of 50 patients (90%) and in 21 of 26 patients (81%), respectively. According to Level III evidence, moxifloxacin was used more often in the surgical wards (Figure 4).

Duration of therapy. The median duration of treatment for CAP and AECB was 7 days (Table 3). The duration of therapy for HAP was slightly shorter (a median of 6 days). Durations for other indications ranged from 5 to 8 days, except for tuberculosis (a median of 22 days).

IV-to-oral step-down therapy. Of the 132 patients, 75 (57%) received IV moxifloxacin; 39 patients (30%) received IV moxifloxacin while concomitantly receiving oral medications. Of these 39 patients, 22 (56%) were given step-down treatment to oral moxifloxacin. The remaining 17 patients (44%) continued with IV moxifloxacin for the duration of treatment.

Adverse drug-related effects. Two patients experienced significant adverse events, resulting in the replacement of moxifloxacin with a therapeutic alternative. In one patient, a maculopapular, erythematous rash improved when moxifloxacin was discontinued. The second patient experienced severe diarrhea, which was associated with the initiation of moxifloxacin; no documentation of improvement was available for this patient.

PDA utility survey. Nine of 13 pharmacists (69%) completed the PDA utility survey (Table 4). Overall, most of the pharmacists supported the use of PDAs as DUE data-collection tools. Six of the nine responding pharmacists (67%) stated that the PDA program was easy to use and did not adversely affect their ability to deliver patient care. Five pharmacists (56%) indicated that they would take part in future PDA-based data-collection studies. On average, the time required for data entry was 4 minutes (range, 2–7 minutes) per patient. In contrast, the average time required to complete data collection via a retrospective chart review was 28 minutes (range, 8–47 minutes) per chart.

Table 3 Median Duration of Moxifloxacin Therapy

Indication	Median Duration, (No. of Days, Range)
First-line therapy	
Acute exacerbations of chronic bronchitis	7 (2–16)
Community-acquired pneumonia	7 (1–15)
Alternative therapy	
Empyema	8 (6–10)
Hospital-acquired pneumonia	6 (2–14)
Intra-abdominal infections	5
Pleural effusion	8 (8–10)
Postoperative pulmonary surgery	7
Skin and skin-structure infections	8
Sinusitis	6
Tuberculosis	22 (16–28)

DISCUSSION

Our goal was to determine the appropriateness of moxifloxacin use at the Vancouver General Hospital and to assess the utility of PDAs as data-collection tools. To our knowledge, this is the only published DUE study of moxifloxacin using evidence-based assessment criteria in accordance with the

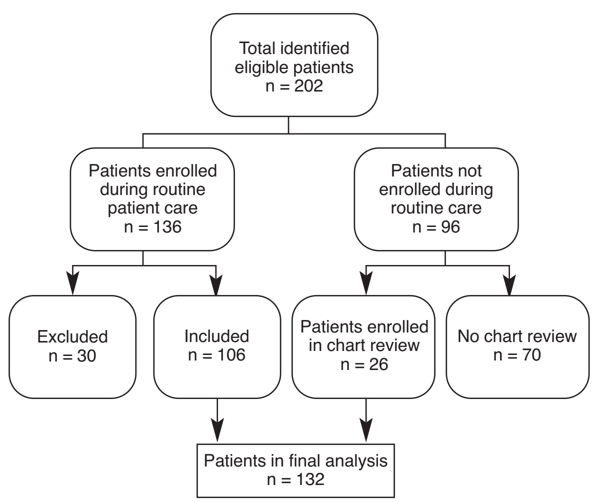

Figure 1 Summary of patient data flow.

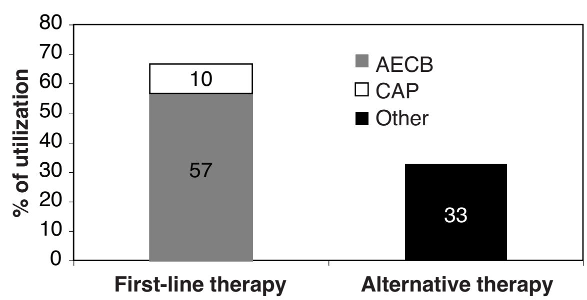

Figure 2 Percentage of moxifloxacin utilization according to assessment criteria (N = 132). AECB = acute exacerbations of chronic bronchitis; CAP = community-acquired pneumonia. "Other" includes empyema, malignant pleural effusion, postoperative pulmonary surgery, tuberculosis, intra-abdominal infections, acute bacterial sinusitis, and skin and skin-structure infections.

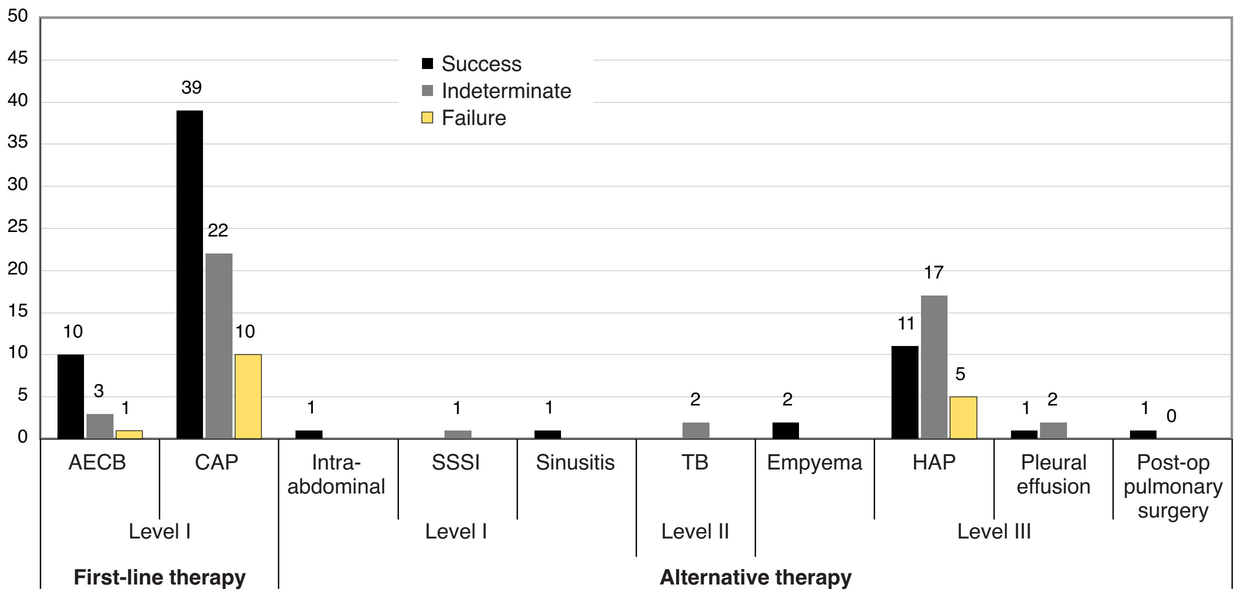

Figure 3 Clinical outcomes according to indication and assessment criteria (N = 129). Success indicates (1) complete resolution of signs and symptoms of infection; (2) clinically significant decrease in symptoms of infection; or (3) healthy upon discharge. Indeterminate indicates no evaluation possible because of insufficient information. Failure indicates (1) persistence or worsening of signs and symptoms of infection necessitating the initiation of an alternative antimicrobial therapy or (2) no significant remission of signs and symptoms (no improvement in baseline parameters). AECB = acute exacerbations of chronic bronchitis; CAP = community-acquired pneumonia; HAP = hospital-acquired pneumonia; Post-op = postoperative; SSSI = skin and skin-structure infections; TB = tuberculosis.

IDSA's levels of evidence grading system in which PDAs are being used as data-collection devices.[12]

Moxifloxacin DUE

In this study, moxifloxacin utilization was appropriate in 89 of 132 patients (67%) and was concordant with evidence-based assessment criteria. The two most common first-line indications were CAP and AECB. Clinical results with moxifloxacin were suboptimal in 43 patients (33%); most of these patients had HAP. These results are consistent with previous fluoroquinolone DUEs, which reported inappropriate usage in 31% to 81% of patients.[3–7,10] Similarly, Belliveau et al., reviewing the use of levofloxacin at an academic teaching institution, determined that its usage was justified only 53.9% of the time.[9]

Moxifloxacin is active against respiratory pathogens in CAP and AECB, as supported by Level I evidence from clinical trials and by IDSA practice guidelines.[15–27] Consequently, moxifloxacin is used extensively at our institution as a primary agent for respiratory infections and is strongly concordant with our assessment criteria. Other possible explanations for the high rate of appropriate use of moxifloxacin include the availability of preprinted physician orders for AECB at our institution, where moxifloxacin is one of the first-line treatment options, and the interventions of clinical pharmacists during daily inpatient medical rounds.

Most of the inappropriate use of moxifloxacin was for HAP, the second most common indication. The role of moxifloxacin in the treatment of HAP is controversial. In clinical practice guidelines from the IDSA and the American Thoracic Society, moxifloxacin is an empirical option for HAP patients who are

Table 4 Results of a Utility Survey on Personal Digital Assistant (PDA) Devices (N = 9)

	1 Strongly Disagree	2	3	4	5 Strongly Agree
Easy navigation through PDA program		11%	22%	67%	
Study participation did not affect delivery of patient care			44%	45%	11%
Willing participation in future PDA-based data-collection studies		11%	33%	56%	
Time (in minutes)	***<2***	***2–4***	***5–7***	***8–10***	***> 10***
Average time (in minutes) to complete required data entry for one patient	11%	45%	44%		

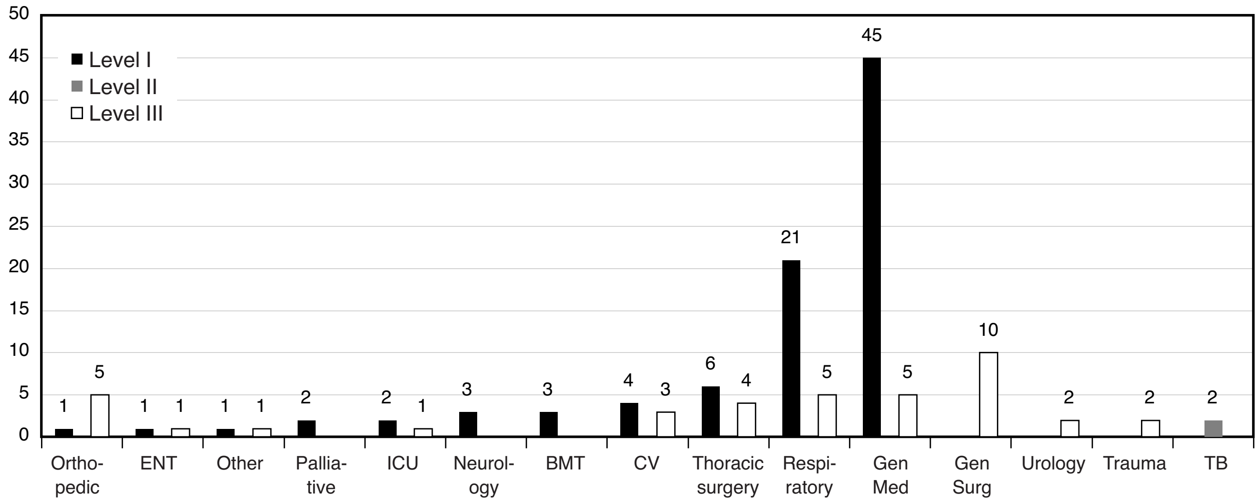

Figure 4 Utilization patterns according to level of evidence and prescribing service (N = 130). BMT = bone marrow transplantation; CV = cardiovascular; ENT = ears, nose, and throat; ICU = intensive-care unit; TB = tuberculosis.

not at risk for multidrug-resistant organisms.[28] However, during our literature search, we did not find Level I support for the use of moxifloxacin in these patients, and moxifloxacin has not been approved for this indication.

Because moxifloxacin is widely used for community-associated respiratory infections, it is important to restrict its use for indications that have the most literature support and benefit in order to reduce its overuse and its potential for resistance. Based on this premise, our Antibiotic Use Subcommittee classified moxifloxacin as an alternative therapy for HAP.

Although moxifloxacin is approved for patients with acute bacterial sinusitis,[29,30] SSSIs,[31,32] and complicated IAIs,[33,34] its use for these indications is minimal. Despite Level I support, our institution has categorized moxifloxacin as an alternative agent for these conditions. The rationale for this decision was the availability of other formulary alternative agents for these infections as well as the need to prevent moxifloxacin overuse and resistance, because moxifloxacin was already used extensively for community-associated respiratory infections. In addition, the "place of therapy" for moxifloxacin was determined based on the level of evidence and other considerations, such as local standards of practice, antibiotic resistance patterns, and the opinion of experts in infectious diseases.[35–38]

Successful clinical outcomes were achieved more frequently with first-line moxifloxacin in contrast to its use as alternative therapy. More successful outcomes were achieved in patients with CAP (39 of 71 patients; 55%) than in those with HAP (11 of 33 patients; 33%). In both indications, successful outcomes were more likely when moxifloxacin was targeted at a known pathogen rather than when it was used empirically. Overall, moxifloxacin was mostly used for the empirical treatment of CAP.

Clinical failures occurred in patients with CAP, HAP, and AECB. In CAP, 10 of 71 patients (14%) experienced clinical failures; this rate was similar to rates reported in other clinical studies.[20–24] The failure rate in patients with HAP was difficult to interpret, because the outcomes were indeterminate for 17 of 33 patients (52%). Possible reasons included the loss of patients to follow-up because of transfers to other medical wards that were not covered by clinical pharmacists and discharge from the hospital. Of 14 patients with AECB, one patient (7%) did not respond to moxifloxacin; this failure rate was comparable with rates in other trials.[15–19]

The medicine and respiratory services prescribed moxifloxacin appropriately in 90% of cases, based on Level I evidence. In contrast, surgical services (cardiovascular, orthopedics, thoracics, and general surgery) used moxifloxacin for non-recommended indications, mostly in patients with HAP. These findings suggest that there is a need for educating the surgical groups on the appropriate use of moxifloxacin. Overall, the median duration of treatment for CAP and AECB was appropriate.

The overuse of IV moxifloxacin was a concern. Thirty-nine patients who received IV moxifloxacin were eligible for oral therapy. Of these patients, 17 (44%) continued with IV moxifloxacin while they also received oral medications concomitantly. These findings are parallel to those of other fluoroquinolone studies, in which suboptimal use was reported in patients who continued on IV therapy despite having no contraindications to oral therapy.[4,8] Because moxifloxacin has high bioavailability (90%), the oral form is the preferred route unless oral absorption or a drug interaction is a concern.[2,4,6,10]

To promote the appropriate use of moxifloxacin, clinicians should adopt strategies aimed at affecting prescribing behavior. These strategies include individual physician prescribing feedback, multidisciplinary in-services that collaborate with infectious-disease physicians, and prescriber education through academic detailing.[4,7,39] Based on the results of our study, emphasis should be placed on educating surgical services groups.

The pharmacist-managed, IV-to-oral dosage-form conversion service at our institution should be reinforced to optimize the oral administration of moxifloxacin and to minimize costs. This approach should be used in conjunction with other established methods, including newsletters, chart talkers, notes, and direct pharmacist–physician interactions.[4,5,7,8,10,39,40]

Personal Digital Assistants: Utility and Challenges

PDAs are useful in guiding point-of-care decisions in diagnostics[41,42] and pharmacotherapy[43–45] and they have the potential to reduce medical errors and improve patient outcomes.[46–49] At Vancouver General Hospital, clinical pharmacists use PDAs each day during routine patient care. The benefits obtained make the PDA an ideal device for the prospective collection of patient information.

In our study, we noted several advantages of PDAs over traditional retrospective, paper-based chart reviews. The real-time data collected via a PDA allowed a more complete capture of information, as the opportunity existed to clarify records and outcomes with health care providers without the need to interpret chart notes. The data-collection time was shortened significantly during point-of-care activities (4 minutes with a PDA vs. 28 minutes with retrospective chart review per patient case). Most important, DUE information can be reported and analyzed in a timely manner because the data are immediately available after the PDA information is synchronized to the central database.

Overall, the pharmacists in our study found PDAs to be effective data-collection tools that required minimal training and that did not hinder the delivery of routine care. Similarly, in a study of the use of PDAs to track treatment with broad-spectrum antibacterial drugs during routine care, Benson concluded that minimal training was required to use the devices; data collection was successful, with a minimal number of incomplete forms; and physicians accepted the additional workload.[12]

The major challenge that we encountered involved the participation of data collectors. All clinical pharmacists on inpatient wards were recruited and trained, but only 69% participated. Because pharmacists visit patients and dispense medications on a rotating basis, a possible cause of their lower rate of participation could have been their unfamiliarity with the study. Therefore, they might have been unaware of the ongoing study, in that training occurred 1 month before the data-collection period. To overcome this obstacle, training should be provided just before data collection and it should be reinforced throughout the data-collection period.

Wireless, automatic synchronization of patient information to the database was not possible with the Palm Pilot Tungsten E/E2 devices used in this study. We anticipate that data collection and transmission will be facilitated with the availability of more technologically advanced hand-held devices.

Based on our results, a PDA data-collection system, together with trained and motivated clinical pharmacists, can be used to prospectively and rapidly collect drug- usage information for analysis within an institution. Possible applications of this system include timely review of drug utilization after the introduction of a new medication, a new drug policy, or a drug safety alert. Such data-collection systems may be custom-tailored to other point-of-care devices, such as the Blackberry, iPhone, iPod Touch, or iPad.

LIMITATIONS OF THE STUDY

Because our investigation took place in only one facility, the moxifloxacin DUE results might not be applicable to other institutions. Nevertheless, the evidence-based assessment criteria can be applied at other sites in order to review the appropriateness of moxifloxacin prescribing.

The assessment was performed over a period of 4 weeks; therefore, our findings might not represent moxifloxacin usage throughout the year. However, the study provides a cross-section of drug utilization at the time of data collection, which can be used to review current practice.

Assessment criteria were derived from evidence in the literature, and the "place of therapy" for moxifloxacin was determined based on local practices. Our intent was to limit moxifloxacin overuse outside of community-associated respiratory infections to prevent resistance.

Because of drug allergies and resistance to other antibiotics, moxifloxacin may have been considered appropriate first-line therapy for conditions that normally would have required an alternative treatment with moxifloxacin. This circumstance, however, was not considered in our study.

Finally, we did not evaluate the dosage or duration of therapy for appropriateness, because the usual dosage for moxifloxacin is standardized at 400 mg daily and the duration of use may vary greatly based on the patient's clinical status.

CONCLUSION

Moxifloxacin use at Vancouver General Hospital appears to be concordant with evidence-based assessment criteria. Further opportunities to optimize the drug's use exist, including medical staff education through academic detailing, in-services, patient-care rounds, and newsletters, as well as optimization of the pharmacist-managed IV-to-oral conversion service. PDAs are feasible data-collection tools that can be used during routine patient care to conduct DUEs. These devices offer advantages over paper-based data collection, and they are relatively easy to use.

Acknowledgment. The authors thank the clinical pharmacists at Pharmaceutical Sciences, Vancouver General Hospital, for their participation and assistance in collecting the patient data for this research study.

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